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From the Editors

Generally speaking, in Melbourne October is the wettest month. But since we have just experienced the hottest September on record, and a number of other weather records have been rewritten in the past couple of years, our expectations of weather perhaps need to be considered anew. Climate change is clearly with us, and will have an impact, not only on the comfort levels of humans, but on all living species of plants and animals.

In this context, field studies of the kind that are reported in this issue of *The Victorian Naturalist* are all the more important. They provide not only a record of what was observed in particular places, but in some cases a base level of information on the activities and environmental contexts of the species under study. The studies reported here are drawn from the widest range of Victoria's biodiversity and provide data that will be of enduring value, particularly in a world of rapidly changing climatic conditions.

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Front cover: Fairy Tern *Sternula nereis* approaching the nest. Photo by Ina Watson.
Back cover: Specimen of *Stenoscyphus inabai* in natural habitat on *Zostera muelleri* July 2012. Photo by Leon Altoff.

Nesting habitat of the Little Tern and Fairy Tern at Lake Tyers, Victoria

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Abstract

This study gathers key baseline data on the vegetation of tern colony sites at Lake Tyers and establishes permanent plots for future monitoring. We characterised the vegetation, substrate type, soil moisture, pH and nutrient levels of Little Tern *Sternula albifrons* and Fairy Tern *S. nereis* colony sites at three islands in Lake Tyers estuary, Victoria. Monitoring plots were established at two colony sites and four non-colony sites, including one abandoned colony site. Vegetation cover was estimated using the point quadrat method. We found that terns nested in areas with 84% ± 1.89 vegetation cover, potentially much higher than reported in previous studies; however, conclusions should be made with caution given the low replication in our study. There was no significant difference in vegetation attributes between colony and non-colony sites. A long-term study including other colony areas along the Victorian coastline would be valuable in understanding colony requirements of these threatened species. This is especially important in the context of the climate change-induced impacts predicted to affect coastal environments in the future. (*The Victorian Naturalist* **130** (5) 2013, 192–201).

Keywords: soil nitrate, vegetation height, seabirds, coastal saltmarsh

Introduction

In Victoria, the Little Tern *Sternula albifrons* and Fairy Tern *S. nereis* are both listed under the *Flora and Fauna Guarantee Act* 1988 as threatened, and are classified as Vulnerable and Endangered, respectively (Reside 2003; Department of Sustainability and Environment 2007, 2009). The Fairy Tern is also listed under the *Environment Protection and Biodiversity Conservation Act* 1999 as Vulnerable. The Victorian distribution of these two species of tern extends along the eastern coastline from Mallacoota to Western Port Bay. In East Gippsland, Little and Fairy Terns are most commonly recorded nesting together on islands in estuaries and occasionally on ocean beaches from Mallacoota to the Gippsland Lakes, though they have also been recorded in far western Victoria (M Weston pers. comm.). For the past five years, the main colony (i.e. breeding) sites used by Little Terns have been in Gippsland: Mallacoota (37°33'0" S, 149°45'0" E), Marlo (37°46'60" S, 148°31'59" E), Tern Island (37°51'5" S, 148°5'29" E), Crescent Island (37°57'4"S, 147°45'31" E) and Corner Inlet (37°45'57" S, 146°20'23" E) (F Bedford and M Bramwell pers. comm.).

Little Terns nest in colonies and nests are typically less than 1.5 m above mean high water (MHW) (Hill 1991). Substrates are usually sandy and the vegetation low and sparse. It is thought that Little Terns avoid nesting in areas with more than 20% vegetation cover, preferring to nest in sparse or scattered vegetation, although this hypothesis has not been rigorously tested (Hill 1991; Owen 1991). Colony sites are created and modified by storms, vegetation encroachment and human activity. The nests of Little and Fairy Terns are typical of those constructed by the Sternidae family, a shallow scrape in the sand, and are often lined with small shells, shell fragments and small pieces of vegetation when available (Reside 2003).

Colony sites in the Gippsland Lakes area have become increasingly important in the maintenance of Little Tern and Fairy Tern populations in south-eastern Australia (Reside 2003). Recent studies, undertaken in the Gippsland Lakes area, suggest Little Tern breeding success is affected by fluctuations in their food source (Taylor and Roe 2004). Why some colony sites have been abandoned remains unknown.

Raven and Plate Islands are the preferred breeding areas in the Lake Tyers estuary and approximately 25 pairs of terns bred at the Lake Tyers estuary in the 2009/2010 breeding season (F Bedford pers. obs.). The two species typically nest together at this location, as they did in the 2009/2010 breeding season. These islands are well vegetated and are periodically inundated.

Considerable variation in plant height and density occurs on the islands, with only small sections used by the terns for breeding. The nearby and larger Tern Island, also well vegetated, is elevated higher above sea level and is inundated only when moderate to severe floods or storm surges occur.

Long-term drought in East Gippsland and artificial opening of the Lake Tyers estuary entrance have caused water levels in the Gippsland Lakes to decrease over the past five years (F Bedford pers. obs.). This has led to concern over potential changes to the Little and Fairy Tern colony sites in Lake Tyers estuary, for example, whether the decrease in water level may impact vegetation on the islands and whether this change would be favourable for nesting or not. Land managers are particularly interested in maintaining Little and Fairy Tern colony sites and, to achieve this aim, colony site characteristics should be quantified.

Our study characterises the physical and vegetative attributes of the colony sites of Little and Fairy Terns at Lake Tyers. Specifically, this study gathers key baseline data on the vegetation of tern colony sites at Lake Tyers and establishes permanent plots for future monitoring.

Methods

Study site

The study area was in the Gippsland Lakes in the Lake Tyers estuary, East Gippsland, Victoria (Fig. 1). The two active colony sites are on Raven and Plate Islands. Raven Island covers 3.5 ha and the colony site area is approximately 50 m × 10 m in size. Plate Island covers 1 ha, with the colony site area covering approximately 60 m × 20 m. Raven and Plate Islands are south of an abandoned (inactive) colony site on Tern Island. Tern Island is larger in size (10 ha) and slightly more elevated. The abandoned colony site examined in this study is situated on the south-eastern tip of Tern Island, where a colony zone (50 m × 50 m) was created from dredge spoil in 1999 (F Bedford pers. comm.).

Vegetation of the islands consists of Coastal Saltmarsh. This Ecological Vegetation Class is restricted to coastal flats subject to the influence of daily inundation and exposure to salt water and poor drainage (Davies *et al.* 2003). Coastal Saltmarsh ranges from a low succulent herbland to shrubland to rushland and sedgeland (Davies *et al.* 2003). Coastal Saltmarsh can comprise several zones. The lowest and most frequently inundated zones are dominated by Beaded Glasswort *Sarcocornia quinqueflora*. The next most landward zone consists of herbs such as: Salt-grass *Distichlis distichophylla*, Creeping Brookweed *Samolus repens*, Shiny Swamp-mat *Selliera radicans*, Rounded Noonflower *Disphyma crassifolium* subsp. *clavellatum* and Southern Sea-heath *Frankenia pauciflora* subsp. *pauciflora*. Sea Rush *Juncus kraussii* subsp. *australiensis* and Chaffy Saw-sedge *Gahnia filum* may dominate the most landward zone (Davies *et al.* 2003).

Sample design

In February 2010, paired sites (colony and non-colony), approximately 80 m apart, were surveyed on each of Plate and Raven Islands. The colony sites have been monitored since 1999 and were designated using visual cues such as nest scrapes and broken eggshell (F Bedford pers. comm.). A single abandoned colony site and a non-colony site were also surveyed on Tern Island. The floristic survey occurred less than 30 days after the Tern breeding season had finished (F Bedford pers. comm.) and no active nests were present. At each colony site, a 6 m × 30 m quadrat representative of the vegetation was positioned parallel to and just above the MHW (Fig. 2). Quadrats in non-colony sites were placed randomly, after stratification according to island, and distance from high-tide mark.

Within the quadrat, three 30 m transect lines were established parallel to the shore line. To enable re-location of the sites, pins and tags were placed at both ends of transects (Fig. 2). The location (easting and northing) of both ends of the centre transect were recorded. Photographs were taken at the four corners of the site, looking towards the centre of the quadrat.

Vegetation cover was estimated for species in the whole quadrat using a modified Braun-Blanquet technique (Mueller-Dombois and Ellenberg 1974) (Table 1). All plant species were identified according to Walsh and Stajsic (2007).

Fine-scale measurements of plant species and substrate (sand, muddy sand, litter, attached litter, driftwood, shell) cover were recorded using

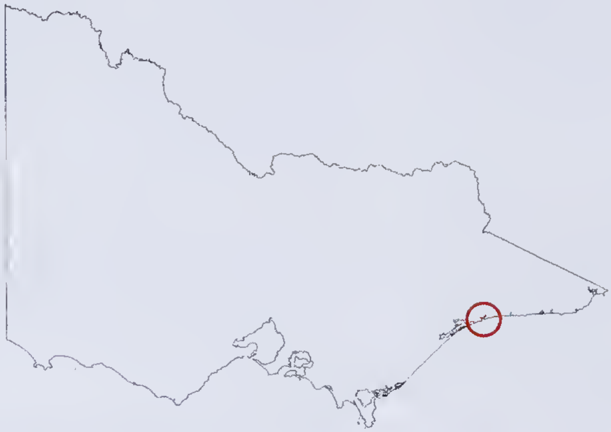

Fig. 1. Location of study site at Lake Tyers and the location of: 1. Tern Island showing the pale coloured abandoned colony site, 2. Raven Island and 3. Plate Island.

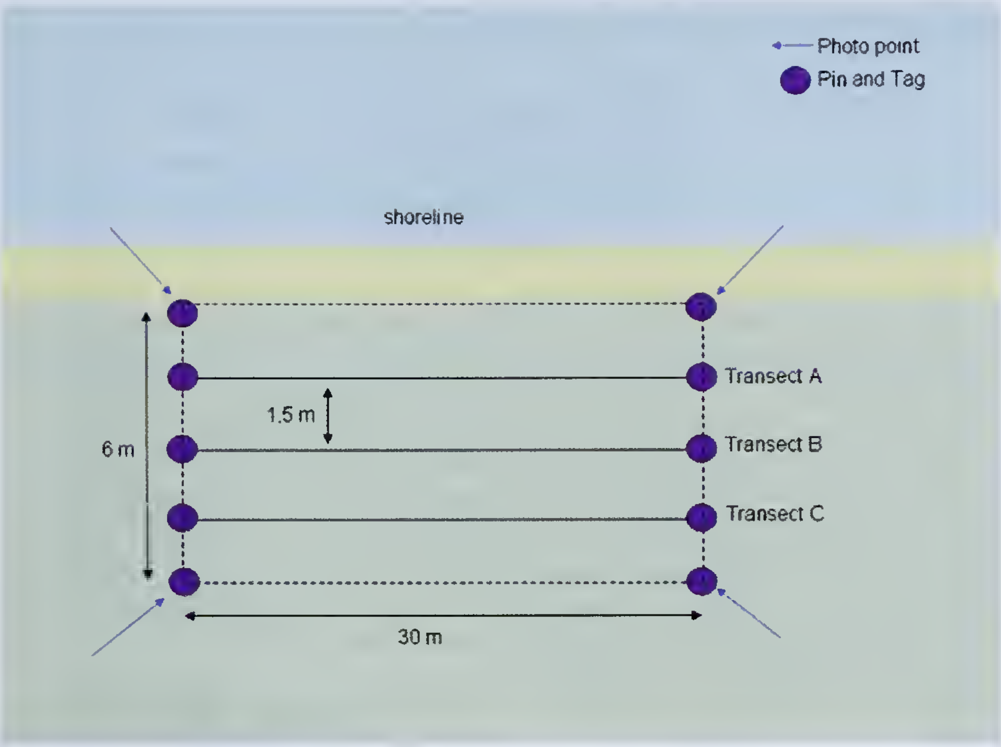

Fig. 2. Schematic diagram of sampling area at each site.

the point quadrat method (Godinez-Alvarez *et al.* 2009) with sampling at 20 cm intervals along each of the three 30 m transects (125 points per transect). This method involves recording the different plant species or substrate that touches a steel pin at given intervals, and since more than one species can touch the pin at each point this can result in a cover abundance of greater than 100% overall. This method is objective and repeatable compared to visual estimates commonly used to estimate cover abundance of vegetation. Furthermore, the precision of cover estimates using the point quadrat method is higher than for visual estimates (Godinez-Alvarez *et al.* 2009). Vegetation height also was measured at 20 cm intervals along the three transect lines using a rising plate meter (Michell 1982). The distance from the edge of the vegetation to the high-tide mark was measured every 1 m along the transect closest to the water.

Three soil samples were taken randomly within each quadrat using an auger. Each sample comprised a core, 0.05 m diameter and 0.1 m depth, incorporating minimal surface litter and avoiding guano. The samples were pooled and a sub-sample was bagged (300–500 g/sample) and subsequently analysed for texture and available phosphorous, total phosphorous, nitrate, ammonium, total nitrogen, potassium, sulphur, organic carbon, total carbon, conductivity, pH ($CaCl_2$), pH (H_2O) and chloride. Analyses were undertaken by CSBP Laboratory (Western Australia). Volumetric soil moisture (expressed as a percentage) was measured within each quadrat, using a theta probe type ML2x (Delta-T Devices, Cambridge, UK) to a depth of 80 mm.

Data Analysis

Plant species data were categorised according to origin, life cycle, and life form. Frequentist statistical analyses were not performed as the potential for significant results was low, given the low replication.

Table 1. Modified Braun-Blanquet cover/abundance scale.

Category	Characters
+	sparsely or very sparsely present; cover very small (< 5%)
1	plentiful but of small cover (< 5%)
2	very numerous, or covering at least 5% of the quadrat area
3	any number of individuals covering 25–50% of the area
4	any number of individuals covering 50–75% of the area
5	covering more than 75% of the area

A principal coordinates analysis (PCO) using the Bray-Curtis dissimilarity index was used to identify differences between the colony and non-colony sites on the basis of (1) plant species and substrate cover and (2) soil characteristics (Legendre and Legendre 1998). PCO was performed using the vegan package in R (Oksanen *et al.* 2011) on data that had been square root transformed and standardised using Wisconsin double transformation (Bray and Curtis 1957; Oksanen *et al.* 2011). PCO was undertaken in R (R Development Core Team 2011). Correlations between dimensions and individual variables were examined using Spearman's rank correlation in R (R Development Core Team 2011).

Results

Vegetation cover and composition

The Little and Fairy Tern colony, non-colony sites and the abandoned colony site were vegetated by coastal saltmarsh. Both colony and non-colony sites were dominated by typical components of coastal, succulent saltmarsh vegetation, namely Creeping Brookweed *Samolus repens*, Narrow-leaf Wilsonia *Wilsonia backhousei* and Beaded Glasswort *Sarcornia quinqueflora*.

The abandoned colony site differed from the other sites in both vegetation and environmental variables. The abandoned colony had the highest cover value of annual species, the lowest cover of perennial species, native tufted graminoids, shrubs and succulents (Table 2). Mean vegetation height was lowest at the abandoned colony site compared to the colony and non-colony sites (Table 2). The vegetation cover of the abandoned colony site was lower (12.8% ± 0.86) than for the colony and non-colony sites (Fig. 3).

Both colony and non-colony sites had a relatively high vegetation cover. The overall mean vegetation cover of colony sites was 84.53% ± 1.89, whilst that of non-colony sites was 96.66% ± 35.32 (Fig. 3).

There was no clear grouping of colony and non-colony sites according to plant species and substrate cover in the PCO (Fig. 4). The first dimension was significantly and positively correlated with Rough Blown-grass *Lachnagrostis scabra* (Spearman's correlation; $\rho = 0.83$, $P = 0.04$). Australian Salt-grass *Distichlis distichophylla* ($\rho = 0.89$, $P = 0.03$) and Knobby Club-sedge *Ficinia nodosa* ($\rho = 0.84$, $P = 0.04$) were significantly correlated with the second dimension. Fifty-nine per cent of the variation between the sites was described by the first and second dimension of the PCO.

Soil attributes

Colony sites had higher nitrates and soil moisture than non-colony sites (Table 3). In terms of soil textural attributes, the colony sites had a higher amount of shell grit than non-colony sites (1% ± 0 and 0.2% ± 0 respectively). The abandoned colony site was characterised by 74% cover of shell grit and had less litter, more bare ground and lower soil moisture than colony or non-colony sites (Table 3).

Eighty-six per cent of the variation between sites, in terms of soil attributes, was described by the first dimension of the PCO (Fig. 5). Variation along this dimension was most significantly negatively correlated with moisture, potassium, conductivity, chloride ($\rho = -1.00$, $P = 0.003$) and clay ($\rho = -0.99$, $P = 0.0003$). There was no clear grouping of colony and non-colony sites according to soil attributes, although the abandoned site was weakly separated on the first dimension.

Discussion

Vegetation attributes of colony sites

At Lake Tyers, Little Tern and Fairy Tern colony sites appear to be characterised by a vegetation cover of 82–85%; however, it should be noted that this is a general observation since there

Table 2. Summary of site vegetation attributes. Data presented are means ± standard deviation for the colony and non-colony site and raw values for the one abandoned colony site.

Vegetation attribute	Colony (n=2)	Non-colony (n=3)	Abandoned (n=1)
Species richness			
Number of plant species	14 ± 1	17 ± 4	13
Species origin			
% exotic	4 ± 5	7 ± 6	23
% native	96 ± 5	93 ± 6	77
Species life cycles			
% annual	22 ± 1	23 ± 6	38
% perennial	74 ± 4	71 ± 4	54
Life forms			
% exotic herb	4 ± 5	7 ± 6	15
% native herb	55 ± 2	59 ± 7	46
% native rhizomatous graminoid	11 ± 5	9 ± 8	15
% native tufted graminoid	15 ± 1	13 ± 4	8
% shrub	15 ± 1	13 ± 4	8
% succulents	56 ± 0	46 ± 20	1
Vegetation height			
Mean height (cm)	5 ± 1	4 ± 2	0.55

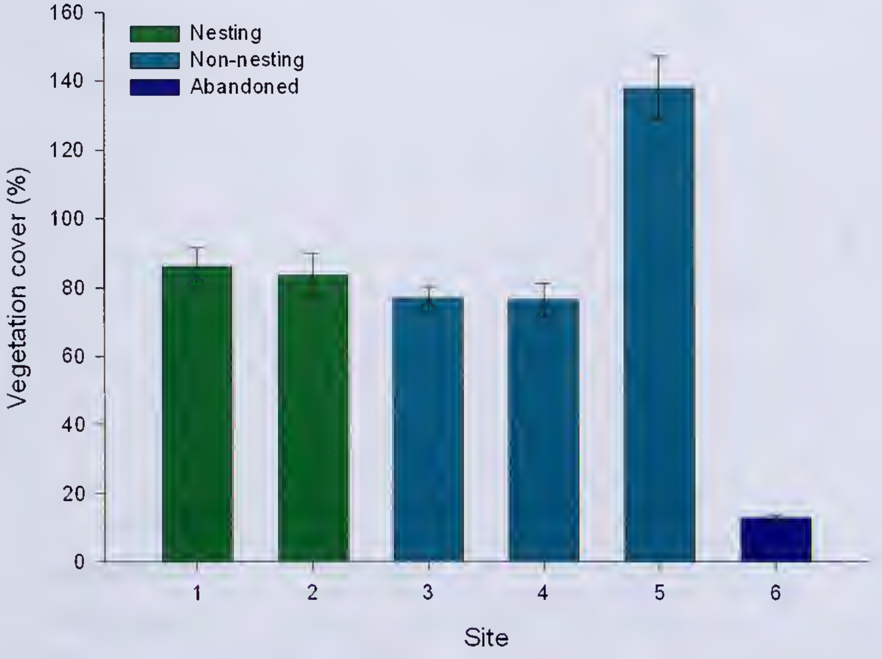

Fig. 3. Vegetation cover (%) across sites. Data are from the point quadrat method and are presented as the mean + standard deviation.

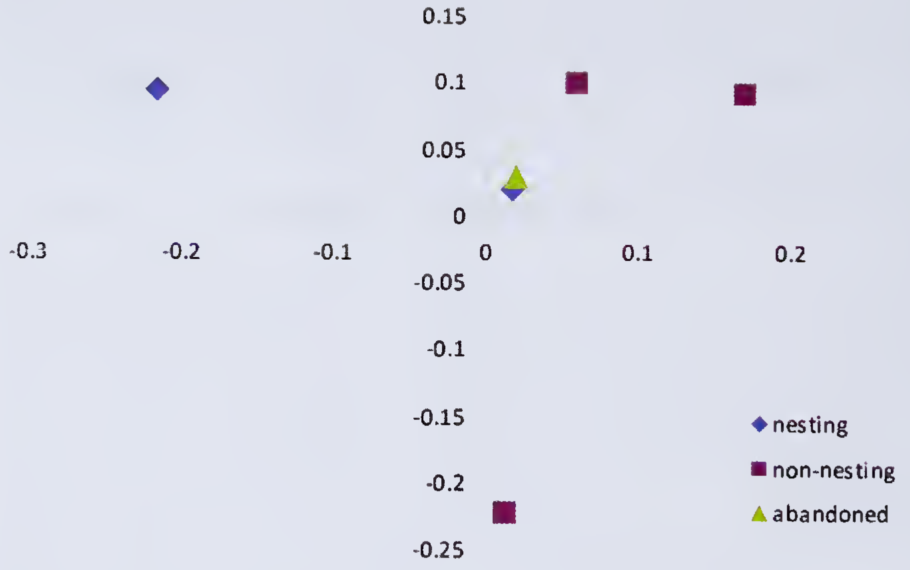

Fig. 4. Principal coordinates analysis plot of mean cover of vegetation and substrate at the tern colony, non-colony and the abandoned tern colony site at Lake Tyers.

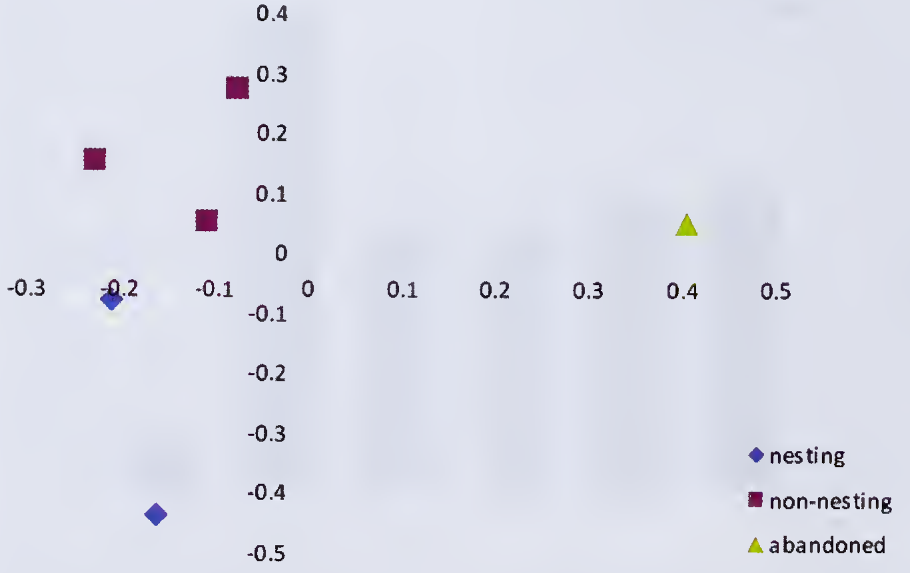

Fig. 5. Principal coordinates analysis plot of soil attributes at tern colony, non-colony and the abandoned colony site at Lake Tyers.

Table 3. Summary of site soil attributes. Data presented are means ± standard deviation for the colony and non-colony site and raw values for the one abandoned colony site. Substrate covers were derived from the point quadrat method.

Site	Colony (n=2)	Non-colony (n=3)	Abandoned (n=1)
Physical attributes			
Mean soil moisture (%)	21 ± 7	17 ± 24	1
Chemical attributes			
Ammonium Nitrogen (mg/Kg)	7 ± 3	4 ± 1	<1
Nitrate Nitrogen (mg/Kg)	6 ± 1	3 ± 1	1
Phosphorus Colwell (mg/Kg)	6 ± 3	3 ± 2	8
Potassium Colwell (mg/Kg)	141 ± 101	258 ± 355	24
Sulphur (mg/Kg)	195 ± 89	456 ± 700	7
Organic carbon (%)	0.3 ± 0	1 ± 1	0.1
Conductivity (dS/m)	2 ± 1	3.8 ± 5	0.1
pH ($CaCl_2$)	7 ± 0	7 ± 1	8
pH (H_20)	8 ± 0	8 ± 1	9
Chloride (mg/Kg)	1389 ± 871	4361 ± 6608	21
Textural attributes			
Clay (%)	5 ± 2	8.1 ± 8	3
Coarse sand (%)	91 ± 4	84 ± 16	94
Fine sand (%)	3 ± 1	3.2 ± 2	2
Sand (%) (sum of fine and coarse)	94 ± 3	87 ± 14	96
Silt (%)	1 ± 1	4.6 ± 5	1
Substrate cover			
Litter (%)	35 ± 2	41 ± 8	0.3
Shell grit (%)	1 ± 0	0.2 ± 0	74
Bare ground (%)	4 ± 4	21 ± 35	74

was a low replication of sites. Nevertheless, this finding is in contrast to previous studies where terns were found to nest in areas where the vegetation cover was less than 20% (Hill 1991; Owen 1991; Department of Sustainability and Environment 2009), and two explanations are possible. It may be that the vegetation cover in previous studies has been underestimated. Alternatively, the terns at Lake Tyers are nesting in suboptimal habitat.

Little and Fairy Terns may choose areas of higher percentage vegetation cover as protection, or perceived protection. The islands in Lake Tyers estuary are frequented by domestic dogs *Canis lupus familiaris*, Red Foxes *Vulpes vulpes*, Silver Gulls *Chroicocephalus novaehollandiae*, Pacific Gulls *Larus pacificus* and Ravens *Corvus* spp. (F Bedford pers. comm). As with other beach-nesting birds, disturbance by predators or humans is likely to influence nesting success of terns (Dowling and Weston 1999; Weston and Elgar 2005). Colony site selection by the Common Tern *Sterna hirundo* is associated with reducing the risk of flooding and accessibility to terrestrial predators (Fasola and Bogliani 1984). These needs are often in conflict, since elevated nest sites are more protected from flooding, but safety from predators requires sites to be at lower elevations since they are less visible (Fasola and Bogliani 1984). Red Foxes sometimes prey upon eggs and young and have caused the abandonment of entire Fairy Tern colonies (Department of Sustainability and Environment 2009). Recreational use of sandy spits and beaches by humans, or even the usage of motorboats nearby, can result in the disturbance of birds from their nests, resulting in chilling or heat stress of eggs and small chicks; trampling of eggs and chicks may also occur (Carney and Sydeman 1999; Dowling and Weston 1999; Weston and Elgar 2005). Such recreational use is common on southern Australian coastlines (Maguire *et al.* 2011).

Less than 20% vegetation cover previously has been reported as being important in tern colony site selection (Hill 1991; Owen 1991). Manage-

ment of tern colony sites in Victoria has, in some instances, involved vegetation removal such as at Werribee (P Menkhorst pers. comm.), Rigby and Crescent islands (Reside 2003) and the Bairnsdale area (Hill 1991; Owen 1991). As this baseline study suggests that terns may be able to nest in areas with vegetation cover higher than previously thought (82-85% cf. <20%), we suggest that any vegetation removal at tern colony sites should be considered carefully.

A potential explanation for the disparity in estimates of vegetation cover at tern colony sites is survey method. Hill (1991) and Owen (1991) used ocular estimates for vegetation cover. When compared, ocular estimates of vegetation cover are typically lower than objective methods such as point quadrats (Godinez-Alvarez *et al.* 2009). Using ocular estimates for this study we would have reported estimated vegetation covers of 40-60%. However, in this study we used the more accurate and repeatable point quadrat method for collecting cover abundance data, leading to higher cover values (Godinez-Alvarez *et al.* 2009).

Saltmarsh vegetation is zoned according to elevation and inundation, resulting in a strong gradient in vegetation composition and height with distance from the high-tide mark (Bertness and Ellison 1987). Little Tern colony sites tend to be less than 1.5 m above high tide mark (Hill 1991). Sample sites in this study, in colony and non-colony areas, were selected controlling for distance from the high-tide mark. Hence, we were searching for differences between sites that were visually/superficially very similar. An important limitation of this study is the low number of sites surveyed: six sites only, with a maximum replication of three, and these were not independent. Low replication is often a problem in studies of threatened species (see Weston and Elgar 2005); however, this study does provide valuable preliminary data on the characteristics of tern colony sites, and a more extensive survey of the Lake Tyers islands, and of colony and non-colony areas along the Victorian coast, could provide greater insight into tern nest site preferences.

Soil attributes of colony sites

Tern colony sites in the Lake Tyers estuary had higher nitrates than non-colony sites. Previous studies report that seabirds can affect the vegetation of colony sites over time via nutrient inputs, and physical disturbance to soil and plants (Gilham 1959; Vidal *et al.* 2000; García *et al.* 2002). Nitrate and phosphate in seabird guano can result in changes to competitive interactions between plant species (Vidal *et al.* 2000; García *et al.* 2002). In particular, vegetation may move from being dominated by native perennial species, to exotic annual species (Vidal *et al.* 2000). Garcia *et al.* (2002) found that the abundance of two chenopod shrubs was influenced by the amount of gull guano present. The abundance of *Suaeda vera* was found to be higher in guano-rich sites, while *Salsola oppositifolia* was the dominant species in areas least affected by seabirds on Mediterranean islands (García *et al.* 2002). Fairy and Little Terns spend only a few weeks each year breeding at the Lake Tyers estuary islands (F Bedford pers. comm) and their effect on the vegetation may be relatively minor. A longer-term study is required to determine if the vegetation of the tern colony sites is changing, and if this change can be attributed to the terns and their associated nutrient inputs.

Characteristics of a human-made, abandoned colony site

The creation of artificial colony sites is considered a potential conservation action for Little Terns (Hill 1991; Owen 1991). At Lake Tyers, the man-made, now abandoned colony site had vegetation and soil conditions that differed from the colony (and non-colony sites); it had the lowest vegetation cover, the lowest relative cover of native tufted graminoids, shrubs and succulents, and the vegetation was, on average, shorter than at active colony sites. Moreover, it had less litter, more bare ground and lower soil moisture than colony or non-colony sites. In the first years after it was created, the artificial site had more vegetation cover and probably greater soil moisture than at the time of survey (F Bedford pers. comm.). The reasons for these changes are unknown. In terms of management, when creating artificial colony sites, vegetation and soil attributes should be as similar as possible to sites where terns do nest. Although the physical attributes of a site are of importance in selection of colony site, social factors, such

as the tendency for birds to return to the same colony site, and social interactions, are also important (Gochfeld 1983).

This study provides key baseline data for the future monitoring of tern colony habitat at Lake Tyers. The methods used in this study were chosen because they are repeatable, and, hence, can be used in a future program of monitoring. We recommend that a longer-term study of tern colonies be undertaken, encompassing more sites from the Victorian coastline. Understanding the colony habitat of these threatened birds is critically important given the changes predicted to affect our coastlines, due to future climate change.

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A Stalked Jellyfish *Stenoscyphus inabai* (Kishinouye, 1893) (Stauromedusae), found at The Jawbone, Port Phillip Bay, Victoria

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Abstract
The stauromedusa *Stenoscyphus inabai* is reported from The Jawbone, Port Phillip Bay and comparisons are made with previous observations made in the 1980s at Black Rock, Port Phillip Bay, with comments on habitat and food sources. Analysis is performed on deformity rates and compared with previous deformity rates reported in Stauromedusae. Colour images of this species are published. (*The Victorian Naturalist* **130** (5) 2013, 202-207).

Keywords: Stauromedusa, Jawbone, *Stenoscyphus inabai*

In 1989 Dan McInnes published an interesting Naturalist Note in *The Victorian Naturalist*, (McInnes 1989). His note was about his observations of a Stauromedusa species, identified as *Stenoscyphus inabai* (Kishinouye, 1893), which he collected at Black Rock and observed in great detail over its life cycle, from small juveniles (0.5 mm) in February–April to mature adults (max. 23 mm) from October to December. Dan noted that while smaller specimens had firm, round, tubular stalks, the mature adults flattened like a flat bicycle tube. His specimens were collected from the weed *Cystophora expansa* (Areschoug) Womersley, a species which is seasonal in growth and is entirely absent in December and January, leading Dan to raise the question: how does *S. inabai* survive when its habitat is absent?

I have recently taken an interest in Stauromedusae, having collected two single specimens over the last 10 years. I have corresponded with Claudia Mills at the University of Washington (Mills 2012) and examined the small collection of Stauromedusae available in Museum Victoria. I was therefore delighted when, on 11 April 2012 on a Field Naturalists Club of Victoria (FNCV) Marine Research Group excursion, I collected 11 specimens of *S. inabai* that were living on *Zostera muelleri*, Irmisch ex Ascherson 1867 at The Jawbone, Williamstown. The 11 specimens were of a range of sizes, including juveniles from 3.5 mm to 8 mm, two specimens (15 mm and 17 mm) being mature with visible gonads, and a third specimen of a mature size (15 mm) which did not exhibit developed gonads. Ten of these specimens (Fig. 1) were retained for photography; as the eleventh was damaged, I released it where it was found.

Robert Burn collected a twelfth specimen some 10 metres away, also on *Z. muelleri* (Fig. 1). This was a 20 mm specimen with a much greener colour and a much greater number of anchors and secondary tentacle groups (16 instead of 8) and rows of gonads (8 pairs instead of 4) (Fig. 2 A, B). The presence of this specimen gave rise to discussion that could be resolved only by examination of further material.

Accordingly, on 7 July 2012 a second visit was made to the Jawbone by Robert Burn, Melanie Mackenzie, Leon Altoff and the author, with the intention of finding more of these animals. It was a cold clear sunny day with an excellent low tide, and the Stauromedusae could be seen easily in the shallow still water, attached to *Zostera muelleri* (Figs. 3 and back cover). In total, about 25 specimens were found, almost all adults with gonads. The colour of specimens varied considerably more than in those seen in April and it was agreed that the bright green specimen from April fell within the colour range of the species.

Fifteen specimens (Fig. 4) were selected to be examined more closely. A range of colours was selected, as were the only two juveniles (8 and 9 mm, with no visible gonads) seen and all adult specimens (14–24 mm), which appeared to be 'fatter' than normal. Of the 15 specimens, 12 had 8 anchors and tentacle groups, the 9 mm juvenile (Fig. 2 G, H) had 9 anchors (which were very small and difficult to count), and appeared to be recovering from damage with a missing peduncle and a slit down one side of the umbrella. A 22 mm specimen had 10 an-

Fig. 1. *Stenoscyphus inabai* specimens collected in April 2012, NMV F190059–F190063.

chors and tentacle groups (Fig. 2 E, F) and a 20 mm specimen had 12 anchors and tentacle groups (Fig. 2 C, D, Fig. 5).

A final visit to the Jawbone on 4 August 2012, in poor weather, yielded a 12 mm juvenile specimen, which was used for live nematocyst observations.

In total, 38 specimens have been seen and three of them (7.9%) have clearly visible additional anchors and tentacle groups, matched with additional rows of gonads, giving perfect pentamerous, hexamerous and octamerous symmetry.

Zagal (2008) observed that of the 3790 specimens of the stauromedusa *Haliclystus antarcticus* Pfeffer, 1889 [as *Haliclystus auricula* (Rathke, 1806) (Miranda *et al.* 2009)] she examined, 16 specimens (0.4%) exhibited pentamerous or hexamerous symmetry. She has suggested that the cause may be either environmental or due to a lack of genetic diversity in the population.

Interestingly, immediately next to the somewhat sparse beds of *Zostera muelleri,* in slightly deeper water, there were luxuriant beds of *Heterozostera nigricaulis* (Kuo 2005) which seemed to be completely devoid of Stauromedusae.

One final observation from this day was of one specimen of the sessile ctenophore, *Coeloplana willeyi* Abbott, 1902, observed in the field on the same seagrass as the Stauromedusae. A second, partially digested, specimen was found inside the umbrella of one of the Stauromedusae. Also found in the collecting jar were two small crustacean carapaces. This suggests that *C. willeyi,* in addition to small crustaceans, is a potential food source for Stauromedusae.

These animals have all been identified as *S. inabai* (Kishinouye, 1893) and not *Depastromorpha africana* Carlgren, 1935, since all specimens lack the remnant primary tentacle and glandular cushions on the outer tentacles.

Examination of discharged live nematocysts and comparison with the table of undischarged nematocysts published in Zagal *et al.* (2011) is not inconsistent with this identification.

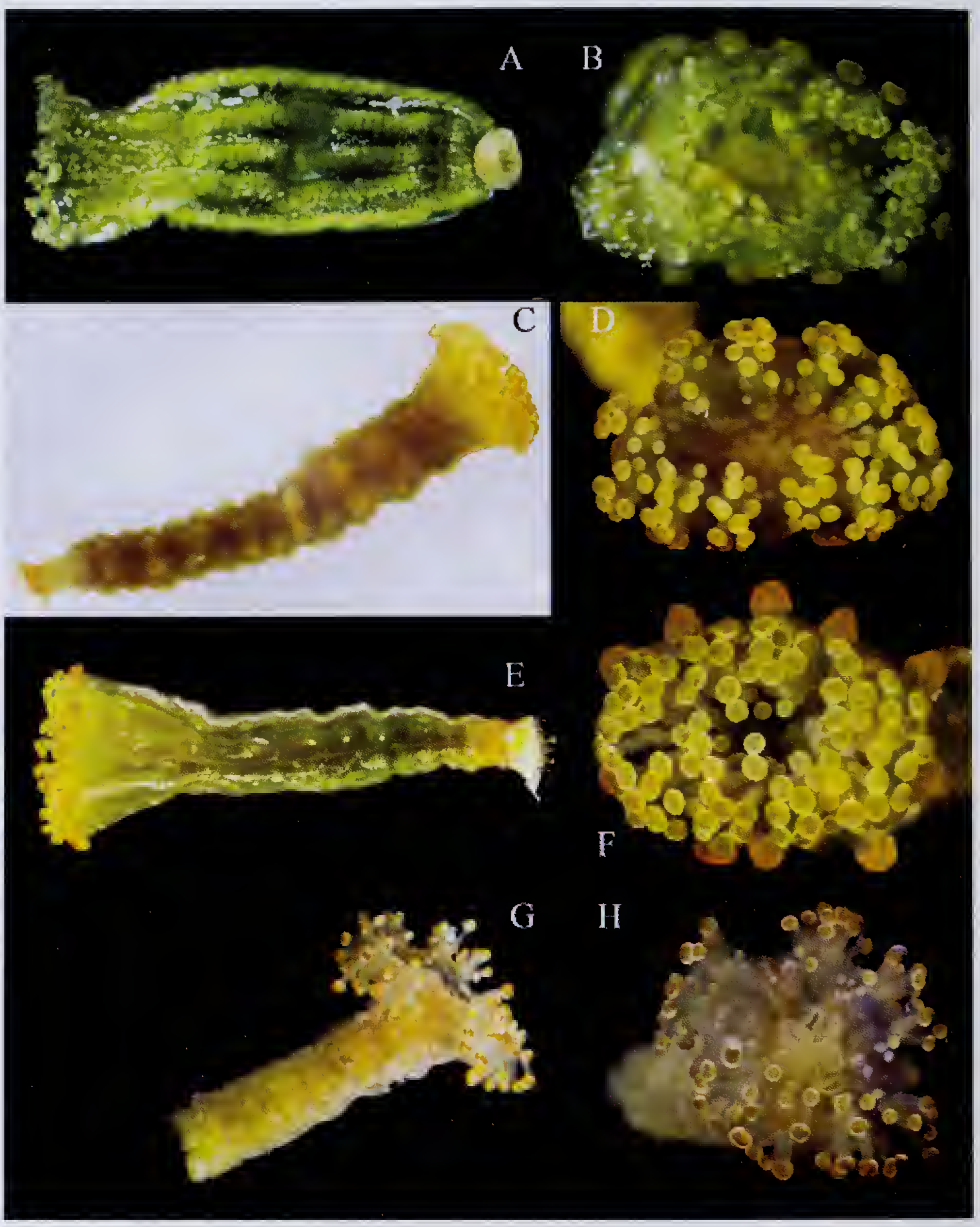

Fig. 2. Deformities of *Stenoscyphus inabai*. A, B Adult specimen, 20 mm, April 2012, NMV F190063; Note octamerous symmetry. C, D Adult specimen, 20 mm, July 2012, NMV F192289; Note hexamerous symmetry. E, F Adult specimen, 22 mm, July 2012, NMV F192289; Note pentamerous symmetry. G, H Juvenile specimen, 9 mm, July 2012, NMV F192289; Note presence of 9 anchors and tentacle clusters, and evidence of damage to bell and missing peduncle.

Fig. 3. Specimen of *Stenoscyphus inabai* in natural habitat on *Zostera muelleri* July 2012.

Fig. 4. Developmental stages of *Stenoscyphus inabai*. A. 3.5 mm juvenile. B. 8 mm juvenile, April 2012, NMV F190059. C-E 15 mm sub-adult, April 2012. NMV F190062. C. Whole animal. D. Note nematocyst clusters. E. Note the beginnings of the development of the gonads and how circular the bell is. F-H Adult specimens (15 mm [NMV F190061] and 17 mm [NMV F190060]) with visible gonads and the "deflated bicycle tyre" appearance. Note that 8 anchors are clearly visible. Bar = 1 mm.

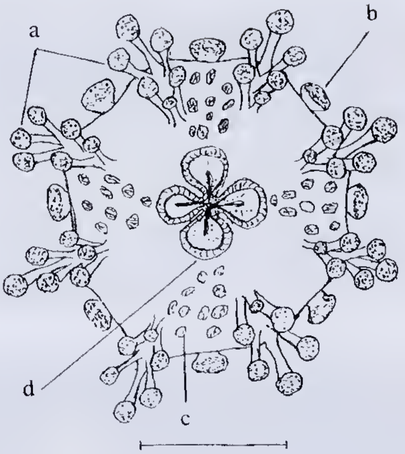

Fig. 5. A view of the subumbrellar or inner side of the bell in an everted position showing a) Secondary tentacles, b) Anchors, c) Nematocyst clusters and d) Four-lobed mouth (bar = 1.0 mm). (Source McInnes (1989: 89).

All specimens collected in April have been photographed in detail and preserved in 96% ethanol to allow for future DNA studies. They have been lodged with Museum Victoria in accordance with the FNCV Marine Research Group's collecting permit, registration numbers NMVF190059–NMVF190063.

The deformed specimens collected in July have been photographed and preserved in 96% ethanol and lodged with the Museum Victoria, registration number NMVF192289.

Dan McInnes' question as to where they go when their habitat is not present still lacks a definite answer. The full life stages of Stauromedusae remain little known and the story of the 'hydropolyp without tentacles', *Microhydrula limopsicola* (Jarms and Tiemann 1996) is instructive (Miranda *et al.* 2010). Specimens of this species, collected on living bivalve shells from the South Shetland Islands on 24 December 1991 and maintained as a live colony ever since (after asexually reproducing and migrating to glass surfaces) were shown to be only a phase of the life cycle of a stauromedusa when DNA analysis was performed and the species synonymised with *Halicystus antarcticus* Pfeffer, 1889 (Miranda *et al.* 2010).

Finally, Kishinouye (1902: 5) notes: 'As the body has adhesive apparatus at both its extremities, it can effect a locomotion very much like that of a leech' (Fig. 3, back cover and Fig. 6).

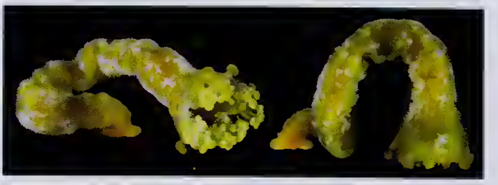

Fig. 6. Specimen of *Stenoscyphus inabai* exhibiting leech-like movement. (15 mm adult specimen, April 2012, NMV F190061).

I am pleased to present here some live colour images of this species' development, behaviour, habitat and deformities.

Supplementary Note

Subsequent to the completion of this paper, a further specimen was observed and photographed by Trevor McMurrich in November 2012 at Curlewis, Outer Corio Bay, Port Phillip Bay. The specimen was found on the seagrass, *Heterozostera nigricaulis* (Kuo 2005) in 50 cm of water and was relocated to a rock to be photographed. It exhibited a vibrant green shade very similar to the octameric specimen collected in April 2012 at the Jawbone. This specimen exhibited normal symmetry.

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I would like to thank Robert Burn and Melanie Mackenzie for their assistance with collecting specimens, Claudia Mills for the many emails about these animals, Jeanette Watson for teaching me how to examine the nematocysts, John Kuo for kindly sending me his paper on *Heterozostera*, Hugh Kirkman for confirming the species of seagrass present at the Jawbone and, finally, Leon Altoff for kneeling for long periods in very cold water in the middle of winter to capture images. I also thank Trevor McMurrich for his interesting observation at Curlewis.

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Release or retain? Prioritising biodiversity conservation when deciding the endpoint for Victorian reptiles and frogs removed from the wild for research purposes

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Abstract

One of several possible endpoints for animals removed from the wild for research purposes is to return those animals (or their progeny) to the wild. However, this endpoint involves risks to wild populations that can be damaging, such as behavioural problems or failure to locate suitable resources, or even catastrophic, such as the introduction or spread of pathogens and disease. Whilst the risk of pathogen transfer can be low for any given release, the consequences when it does occur can be extreme. Risks such as transferring novel or emerging pathogens from captivity to wild populations can occur before pathogens are known to occur. This situation occurred with the introduction to Australia of the amphibian disease chytridiomycosis, which probably entered wild populations via infected captive frogs before the pathogen that causes the disease was identified. I argue that reptiles and frogs removed from the wild in Victoria should not be returned to the wild, and discuss some alternative endpoints for these animals. (*The Victorian Naturalist* **130** (5) 2013, 207–211).

Keywords: research, reptiles, frogs, release, retain

Biodiversity is under increasing pressure around the world (Butchart *et al.* 2010), and reptiles (Gibbons *et al.* 2000; Sinervo *et al.* 2010; Böhm *et al.* 2013) and amphibians (McCallum 2007) are conspicuous components of global biodiversity loss. In fact, loss of amphibians due to the disease chytridiomycosis, caused by the Amphibian Chytrid Fungus *Batrachochytrium dendrobatidis*, over the last few decades has been labelled 'the most spectacular loss of vertebrate biodiversity due to disease in recorded history' (Skerratt *et al.* 2007: 125). Protection and restoration of biodiversity is the primary objective of conservation agencies.

Numerous researchers (> 12 in 2012; author's unpublished data) apply to the Victorian Department of Environment and Primary Industries (DEPI) (formerly Department of Sustainability and Environment) each year for a permit to allow them to collect reptiles and/or frogs within Victoria for research purposes. Typically, these applications fall into one of two categories: those for which returning the animals to the wild is an integral component of the experimental design, and those for which there is no research need to return animals to the wild. It is important to distinguish between returning animals to the wild at the conclusion of a **research** project (the subject of this paper), versus the numerous wildlife **management** projects involving animal releases that occur in Victoria and have Management Authorisations under the *Wildlife Act* 1975. These latter projects must meet strict criteria and have appropriate approvals, and the issues addressed in this paper are typically considered and managed during those projects.

Any movement of animals from captivity to the wild involves risks. These include: introduction or spread of pathogens from captive to wild populations (e.g. Jacobson *et al.* 1991; Picco and Collins 2008; Allender *et al.* 2012), moving animals beyond their existing range (Lever 2001), elevated rates of predation due to unfamiliarity with the field site and retreat locations (Bennett *et al.* 2013), unavailability of biotic and abiotic resources due to competition with conspecifics, and intraspecific aggression or territoriality from wild conspecifics (e.g. Done and Heatwole 1977).

In terms of disease impacts, unknown or novel pathogens may be the most devastating due to host naiveté, because the pathogens may not be evident or understood for some time after release, or because no consideration is given to their management. For example, it is likely that once-captive amphibians contributed to the spread in the wild of the Amphibian Chytrid Fungus and, thus, contributed to losses of frog populations before this pathogen was even known to exist (e.g. Farrer *et al.* 2011). Because of the risk of disease transmission in amphibians during research projects, Phillott *et al.* (2010: 9) recommend 'when assessing permits for such an activity, wildlife conservation agencies and ethics committees should view animals taken from the wild as a permanent take'. Even if the vast majority of cases of returning animals to their point of capture result in no introduction of pathogens, it takes but a single transfer of a devastating pathogen (such as the Amphibian Chytrid Fungus) to cause massive losses of wild populations. And, remaining with the Amphibian Chytrid Fungus example, pathogen screening would not have detected this pathogen at the time that it was initially spreading in Australia because the pathogen was unknown for more than a decade after its introduction. Furthermore, some amphibian species can carry the fungal pathogen without exhibiting the disease chytridiomycosis (Reeder *et al.* 2012); consequently, quarantine would not have necessarily prevented captive to wild transmission of this pathogen.

Retaining collected animals also involves some risks, including the loss to the 'donor' population of the animals collected for the research. This impact is assessed by the DEPI during the permit processing procedure, and, if the collection is supported, will typically be considered negligible, based on best available information at the time. Most research projects involve collection of a relatively modest number of Victorian reptiles and amphibians (pers. obs.); if the impact of collection was deemed not to be negligible, and the population was thought to be unable to cope with such collection, the collection is unlikely to be supported in the first place.

Animal Ethics Committees (AECs) and researchers applying for a permit from the DEPI are often adamant that threatened species removed from the wild for research be released at the conclusion of the project (author's pers. obs.); however, few species are so threatened that minor, judicious collecting will adversely affect a population; if they are that threatened, they should not be collected at all (unless as part of an approved conservation program that necessitates such collection).

Frequently, release of animals is expected (or even demanded) by AECs and applicant researchers with little or no justification for why the animals must be released; when queried on their motivation to return the animals to the wild, the reasoning is usually emotive or based on anthropomorphising of the animal's fate (author's pers. obs. For another example of an AEC applying emotive reasoning, see Jones *et al.* 2012). The need to return reptiles and frogs to the wild must be justified by the researcher or the relevant AEC. This justification should explain how the risks mentioned above have been quantified, and how they will be managed. Furthermore, if release is intended, a funded post-release monitoring program of sufficient duration and intensity to assess the fate of released animals, and other relevant species at the release site, should be implemented. Animal Ethics Committees' unfamiliarity with many species' ecology frequently results in advice that, whilst undoubtedly well-intentioned, could result in undesirable outcomes for the individual animals involved (pers. obs.). If AECs facilitated an open exchange of information between themselves, applicant researchers and experts on the study species, the most ethical endpoint for study animals is more likely.

Wildlife research is a scientific, evidence-based field, and AECs typically demand that applicant researchers provide justification for their work, evidence of why animals must be collected, and citations to justify collection and scientific methods. These committees should be under the same burden of proof when justifying and validating their recommendations, including directives to return animals to the wild. If an AEC cannot demonstrate that the benefits of release outweigh the risks inherent to release, their directives to release lack credibility.

If release is part of the research design

If release of Victorian reptiles and frogs is a component of the experimental design, the following factors must be considered:

- If they are not part of a translocation program approved by the DEPI, are the animals being returned to their precise collection location?
- Have the animals been housed away from other animals? Have the animals been subject to adequate quarantine standards and durations?
- Prior to release, has an adequate sample of animals been subjected to appropriate pathology tests?
- Can the researcher prove that all risks have been adequately managed (disease, predation, intraspecific aggression, territoriality, enough resources)? A number of these factors are typically overlooked or down-played by AECs.
- Does the researcher/AEC have an adequate contingency plan if the monitoring program suggests that the release is problematic for any reason? For example, if disease is introduced or spread, how will this be remedied? If released animals are harassed or killed by conspecifics, how will this be addressed?

Fate of retained animals

There are various potential endpoints for retained animals, including:

- The animals may be suitable for further research projects. This can minimise further collection of wild animals.
- The animals may be kept *in perpetuity* at the research facility (this will necessitate an additional permit).
- The animals may be transferred to a zoological park (this will require a willing zoological park and approval from the DEPI).
- Subject to approvals, and alignment with the captive schedules of the *Wildlife Regulations* 2013, the animals could be transferred to the captive trade.
- Some or all of the animals could be humanely euthanised, preserved, and submitted to Museum Victoria. Comparatively few specimens are contributed to the Museum in the modern era, and submission of these specimens will benefit the collection (e.g. Payne and Sorenson 2002; Feeley and Silman 2011; Joseph 2011; Kemper *et al.* 2011), albeit in a manner geographically biased by the research aims and methods.

Where large numbers of animals are used in a project, a combination of these endpoints could be considered.

Put simply, if biodiversity conservation is an overriding consideration, minimising risks to wild populations must take precedence over the liberty of the small numbers (relative to those remaining in the wild) of individuals used each year for research. This position may be summarised thus:

> If the risk to biodiversity of releasing reptiles and frogs is greater than zero (and it invariably is), and the benefits to biodiversity of such release are zero or unknown (and they usually are), and release is not an integral component of the experimental design, animals should not be returned to the wild (Fig. 1).

In order to put into practice the oft-cited desire to minimise risks to biodiversity, researchers seeking a permit to collect Victorian reptiles and frogs, and the AECs that are charged with overseeing the ethical use of animals in research, must either accept that removal from the wild of animals for research is a permanent take, or that they must bear the burden of proof that releasing these animals will have no conceivable impact on biodiversity.

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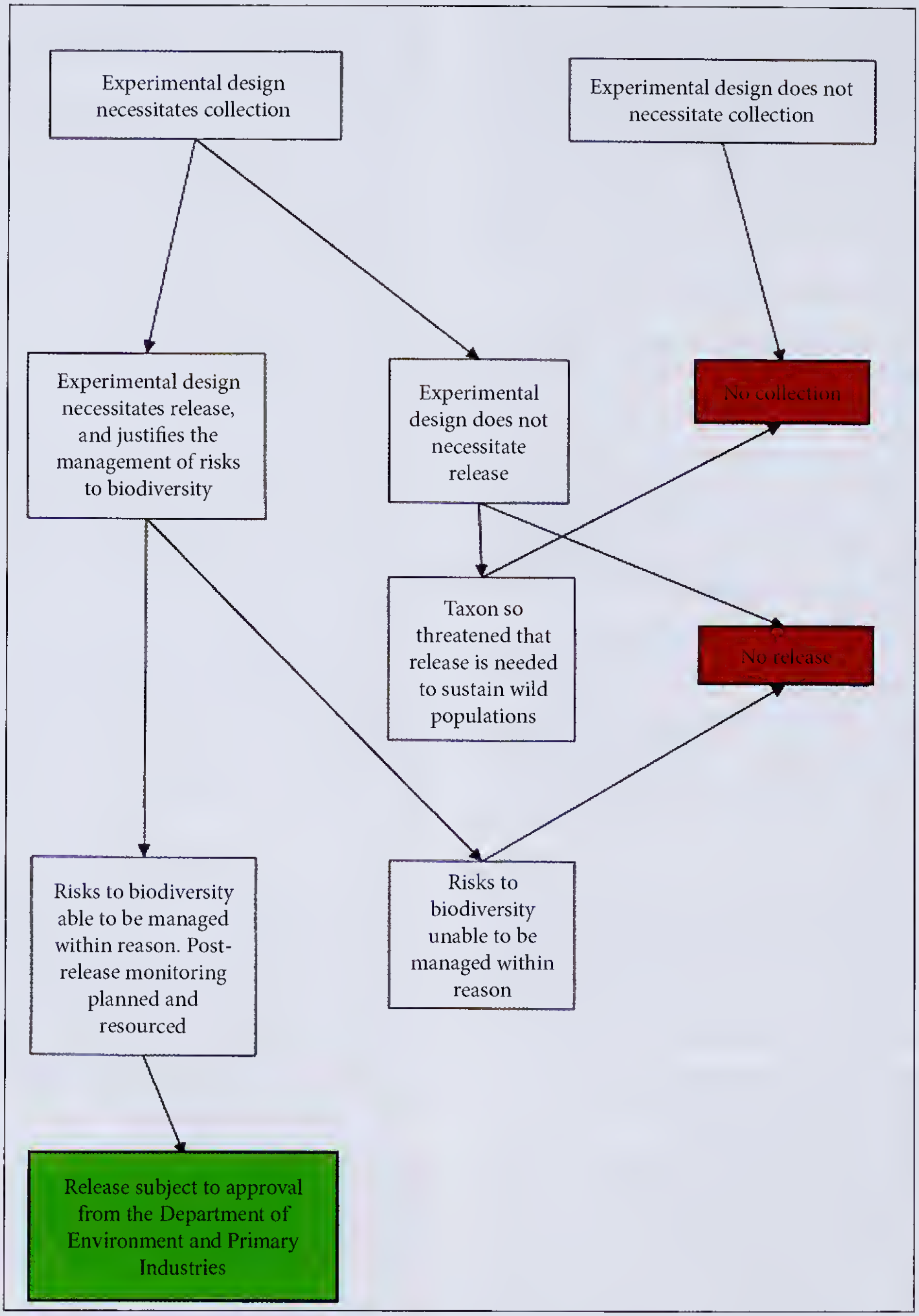

Fig. 1. Deciding on the use and ultimate fate of Victorian reptiles and frogs removed from the wild for research.

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Ninety-Nine Years Ago

SOME COASTAL PLANTS: THEIR SHELTER VALUE AND FIRE DANGER.
BY T.S. HART, M.A., B.Sc.

THE prevalent coastal tea-tree scrub is well known to be highly inflammable; but any extensive removal of vegetation on an open, sandy coast, either to make clear fire-breaks or by general thinning, would be likely to lead to serious and increasing sand-drifting. The practical problem becomes that of preserving a sufficient covering of vegetation of the least inflammable kinds possible. … I have recently made some rough tests of the ease of ignition of the foliage of several species …. The results may be summarized as follows :—

1. Most inflammable, quick ignition, and plenty of flame—
Leptospermum laevigatum, Coast Tea-tree, and *Leucopogon Richei*, Native Currant.
2. Easily ignited—*Bursaria spinosa*, Sweet Bursaria, *Correa alba*, White Correa, *Casuarina quadrivalvis*, Drooping Sheoke.
3. Fire-resisting plants—*Acacia longifolia*, var. *sophorae*, Coast Wattle, *Rhagodia Billardieri*, Sea Berry, *Tetragonia implexicoma*, Warrigal Cabbage, *Muehlenbeckia adpressa*, Climbing Lignum, *Myoporum insulare*, Boobialla—especially the last three, but the others were not far behind.

From *The Victorian Naturalist* **xxx**, p. 222-223April , 1914

A trial of slash and burn management of Coast Tea-tree *Leptospermum laevigatum* on Wonthaggi Heathland

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Abstract
In 2000, a trial program of management of the Wonthaggi Heathland Nature Conservation Reserve was implemented. This used the slash and burn technique in small patches of vegetation. The aims were: to assess the invasion of Coast Tea-tree *Leptospermum laevigatum*, to determine the effect of each treatment on species richness and to observe the response of weeds and orchids. Post-treatment monitoring was carried out in 2008, 2009 and 2012. The results from this trial show that these management strategies reduce the invasion of Sand and Wet Heathland EVCs by Coast Tea-tree and enhance species diversity. It would be appropriate to extend the area of management and continue to monitor the results over the long term. (*The Victorian Naturalist* **130** (5) 2013, 212–218).

Key Words Coast Tea-tree, slash and burn management, Sand and Wet Heathland

Introduction

Wonthaggi Heathland Nature Conservation Reserve (WHNCR) covers 811 ha extending from the outskirts of Wonthaggi south to the coast and east to Harmers Haven. The vegetation has been mapped as Sand and Wet Heathland (EVCs 6 and 8) and Coast Banksia Woodland (EVC 2), with Coast Dune Scrub Mosaic (EVC 1) along the dunes (Davies *et al.* 2002). In 1985 large sections of the reserve were burnt. Since then there have been controlled burns over small areas in different parts of the reserve in 2000, 2007, 2008, 2009 and 2010. These burns were part of the fire prevention management plan to reduce the fuel load in a reserve close to the town and as ecological burns to enhance biodiversity.

Over the last couple of decades the invasion of Coast Tea-tree *Leptospermum laevigatum* into heathland vegetation has become a significant concern for the Friends of Wonthaggi Heathland, volunteers who care for the heathland and work closely with Parks Victoria. Their concern is that Coast Tea-tree does not belong in Sand and Wet Heathland (Davies *et al.* 2002) and that its invasion may reduce the biodiversity of these EVCs.

In addition, this reserve is one of the sites used in the study of the rare and threatened Eastern Spider Orchid *Caladenia orientalis* by the Department of Sustainability and Environment (DSE) (now Department of Environment and Primary Industries). It is important that management should not have an adverse impact on this species.

Coast Tea-tree develops as a small, single-stemmed tree reaching a height of 8-12 m, with a life span of 100-150 years. Although the trees are killed by fire, seeds are not, as they are protected by the hard woody capsules. These capsules drop from the plant and remain closed, but open soon after a fire. Germination is prolific in the following winter (Burrell 1981). As many as 400 seedlings per square metre (M Ellis pers. obs.) germinated post-fire at Wilsons Promontory National Park (WPNP) in 2006. Seed is usually viable for one year. Most seeds germinate in the first year after a fire.

Invasion of Coast Tea-tree into heathland shows a variety of effects caused by fire. Burrell (1981) showed that three factors were necessary to produce extensive areas of Coast Tea-tree: disturbed topsoil, a temporary increase in soil phosphorus level and release of the accumulated reservoir of seed. Fire was suggested as the factor likely to produce these conditions; however, Bennett (1994) considered that fire was not a pre-requisite for Coast Tea-tree expansion on the Yanakie Isthmus at WPNP, but that grazing pressure may have been the cause, due to the exposure of bare ground and the restriction of the feeding range of cattle. Fire suppression was a possible cause of invasion of

Coast Tea-tree into remnants of Heath Tea-tree *Leptospermum myrsinoides* heathland in suburban areas of Melbourne (Browning 2004). It is, therefore, appropriate to test the effect of fire *in situ* in order to develop a management strategy for the WHNCR.

Methods

In 2000, a trial program of management of the reserve was implemented using slash and burn in small areas of vegetation, with the aims: to assess the invasion of Coast Tea-tree, to determine the effect of each treatment on species richness and to observe the response of individual species of weeds and orchids where appropriate. Plant species were named according to Walsh and Stajsic (2007).

An area of approximately 6 ha was selected for the trial (Fig. 1). Within this area, four permanent 20 × 20 m quadrats (A, B, C and E on map) were established. A control quadrat (D) was set up in the long-unburnt area. It may be 30 to 40 years since this was last burnt. The treatments for each quadrat were as follows: A. Dry Tea-tree was burnt in 2002, slashed in mid 2007, burnt in 2010; B. Dry Tea-tree was burnt in 2000, slashed in mid 2007 and burnt in 2008; C. Dry, light cover of Tea-tree was burnt in 2000 and 2008; and E. Moist Tea-tree, burnt in 2000 and 2008.

Vegetation monitoring was carried out in October 2008, September 2009 and October-November 2012. Quadrats (1 × 1 m) in the centre and in each corner of the 20 × 20 m quadrats were examined, recording all species present and all Coast Tea-tree seedlings. We also recorded any additional species present in the 20 × 20 m quadrat. Exact counts of species and seedlings were possible in all the treatments. In the control D, only a rough calculation of the total number of mature Coast Tea-trees could be made, by multiplying the mean number in 1 × 1 m by 400 as the quadrat was virtually im-

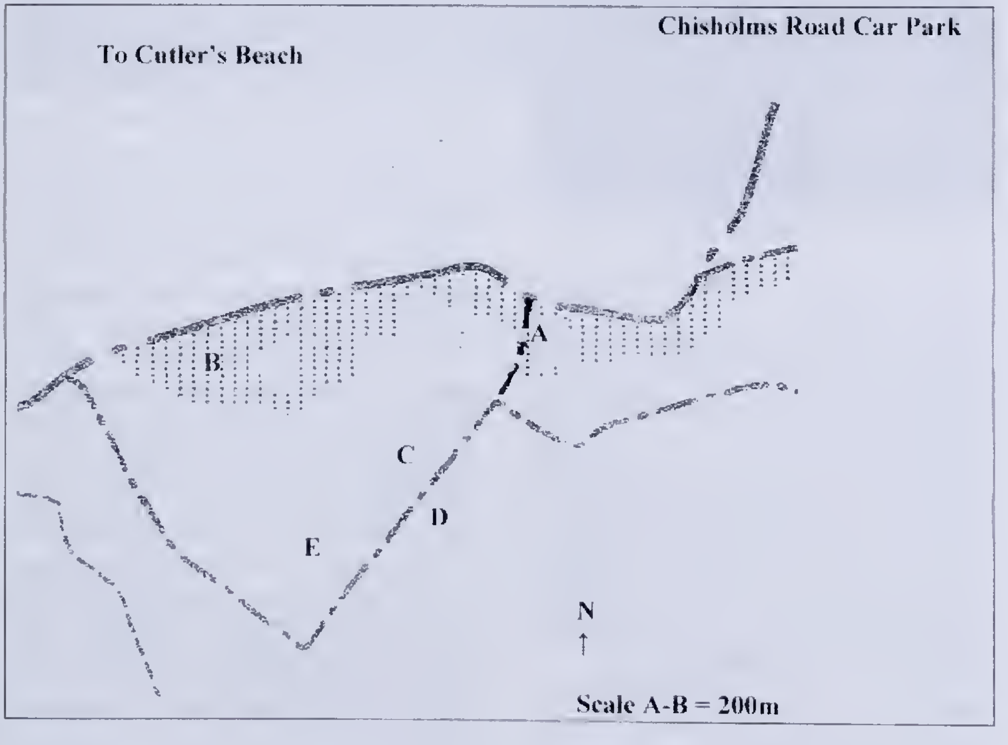

Fig. 1. Location of quadrats in trial area. Shaded area was slashed in 2007.

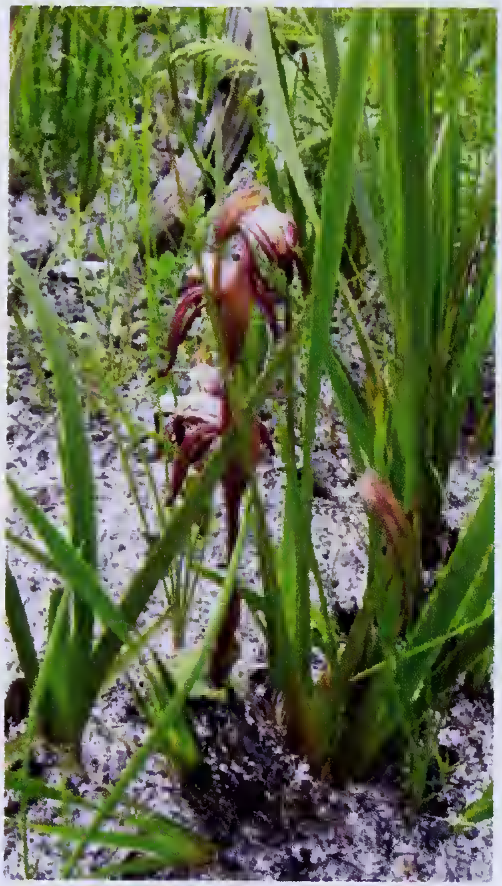

Fig. 2. Redbeaks *Pyrorchis nigricans*.

Fig. 3. Eastern Spider Orchid *Caladenia orientalis*.

penetrable, with access on hands and knees to each 1 × 1 m quadrat.

We have presented the results as tables of means per five 1 × 1 m quadrats and the total number of species in 20 × 20 m quadrats for the three field days.

In October 2008, following fire the previous autumn, there were numerous Redbeaks *Pyrorchis nigricans* (Fig. 2) flowering on the heathland. Using four of our 1 × 1 m quadrats we counted the total number of Redbeaks per square metre and the number flowering. We also counted Eastern Spider Orchids *Caladenia orientalis* (Fig. 3) in the same area.

Results

Invasion of Coast Tea-tree

There is almost no recruitment of Coast Tea-tree under mature closed-canopy tea-tree heath. This is borne out in the data for the control D (Table 1). In treatment A, there was considerable recruitment in the first two years after slashing, but it was reduced to the control level within two years of the 2010 burn. The lowest recruitment occurred in treatment B with two burns and slashing one year before the second burn. In treatments C and E there were similar results except for one anomaly in treatment C, 69 seedlings in the north east corner, possibly from one parent plant, after the burn in 2008.

The effect of each treatment on species richness

The only quadrat with mature Coast Tea-tree is the control (D) where the lowest number of understorey species was found (Table 2).

In the first year after the fire, species diversity as determined by counting the number of species present in 20 × 20 m quadrats was very similar in all treatments as well as the control (Table 3). By the second year there were greater numbers. The numbers all dropped by the fourth year after the last fire.

The regrowth of vegetation after the fire produced a dense heath in all treatments with less than 20% bare ground and a height of less than 1 m in the first year and up to 1.25 m by the

Fig. 4. The dense heath in quadrat B, November 2012.

fourth year (Fig. 4). In the control quadrat, the mature Coast Tea-tree reached 4 m in height, bare ground was 20% and litter 70%. There was no litter in the treatment areas.

Response of weeds
There are very few weeds on the heathland and only two species were recorded in the quadrats. Dandelion *Taraxacum officinale* occurred in three 1 × 1 m quadrats in 2008 and Cat's-ear *Hypochoeris radicata* was found in seven 1 × 1 m quadrats in 2009 and in one quadrat in 2012. In every instance the percentage cover was just a trace.

Response of orchids
In October 2008, there were numerous Redbeaks leaves per square metre, a quarter of them with flowers. Of Eastern Spider Orchids in the same area, half of them were in flower (Table 4).

In the trial quadrats the number of orchid species found was very low compared with the total number of orchid species known to occur in the Reserve (Table 5). Over a lifetime of visiting the Reserve, 74 species have been recorded (T Allen pers. obs.).

Discussion
The primary value of the trial is that detailed observations were made so that we have a measure of the effect of the treatments on the invasion of Coast Tea-tree, on species richness, on weeds and on two orchid species, one of which is a known fire response species and one which is rare. This was a small trial in a restricted area, but accumulation of results from similar work elsewhere can elucidate appropriate management strategies and are worth reporting.

Mature Coast Tea-tree does not burn easily because there is so little fuel underneath the canopy; slashing prepares a fuel load that will burn readily. Given that Coast Tea-tree capsules don't open until dropped, that seeds are only viable for one year and that it is a fire responsive species, slashing a year prior to burn-

Table 1. Mean Number of seedling Coast Tea-tree in five 1 × 1 m quadrats.

Quadrat	EVC	Treatment	Date	Mean
A	Sand Heathland	Burnt 2002, slashed 2007, burnt 2010	6/10/08	14.8
			24/9/09	30
			25/10/12	2.6
B	Sand Heathland	Burnt 2000, slashed 2007, burnt 2008	6/10/08	2.4
			24/9/09	1.4
			19/11/12	1
C	Sand Heathland	Burnt 2000, 2008	6/10/08	13.8
			24/9/09	0.6
			25/10/12	5.2
D	Sand Heathland	Control unburnt 30-40 years	6/10/08	0
			24/9/09	0
			25/10/12	2.6
E	Wet Heathland	Burnt 2000, 2008	6/10/08	6.4
			24/9/09	5.4
			25/10/12	0.2

Table 2. Mean number of understorey (U) and total number of canopy (C) species in five 1 × 1 m quadrats.

Quadrat	EVC	Treatment	Date	Mean U	Mean C
A	Sand Heathland	Burnt 2002, slashed 2007, burnt 2010	6/10/08	13.2	0
			24/9/09	13	0
			25/10/12	19.6	0
B	Sand Heathland	Burnt 2000, slashed 2007, burnt 2008	6/10/08	10.4	0
			24/9/09	15.4	0
			19/11/12	8.6	0
C	Sand Heathland	Burnt 2000, 2008	6/10/08	12.2	0
			24/9/09	17.8	0
			25/10/12	15.6	0
D	Sand Heathland	Control unburnt 30-40 years	6/10/08	7	8
			24/9/09	6	5
			25/10/12	6.4	6
E	Wet Heathland	Burnt 2000, 2008	6/10/08	18.2	0
			24/9/09	21.6	0
			25/10/12	10.2	0

Table 3. Total number of species in 20 × 20 m quadrats on each field day.

Quadrat	EVC	Treatment	2008	2009	2012
A	Sand Heathland	Burnt 2002, slashed 2007, burnt 2010	36	44	55
B	Sand Heathland	Burnt 2000, slashed 2007, burnt 2008	31	60	41
C	Sand Heathland	Burnt 2000, 2008	38	59	40
D	Sand Heathland	Control unburnt 30-40 years	33	35	22
E	Wet Heathland	Burnt 2000, 2008	31	40	32

Table 4. Mean number of orchids present and percentage (%) flowering.

Orchid spp.	Scientific name	Total	Flowering	% flowering
Redbeaks	*Pyrorchis nigricans*	186	47	25
Eastern Spider Orchids	*Caladenia orientalis*	50	25	50

Table 5. Number of orchid species found in 1 × 1 m quadrats.

Quadrat	EVC	Treatment	2008	2009	2012
A	Sand Heathland	Burnt 2002, slashed 2007, burnt 2010	0	1	3
B	Sand Heathland	Burnt 2000, slashed 2007, burnt 2008	1	4	0
C	Sand Heathland	Burnt 2000, 2008	4	5	3
D	Sand Heathland	Control unburnt 30-40 years	0	0	0
E	Wet Heathland	Burnt 2000, 2008	1	0	1

ing may remove viable seeds, so that the burn does not stimulate germination. At WPNP, after the 2005 fire, the mean number of stems of Coast Tea-tree in 1 × 1 m quadrats was more than 200 in the first year, decreasing slightly in the second year and down to 150 by the fourth year post fire (Tolsma and Cheal 2012). This is 10 times the number of stems recorded in the Wonthaggi trial. They also noted a very low level of recruitment of Coast Tea-tree in unburnt sites at WPNP.

After germination it takes only four years before Coast Tea-tree plants flower and set seed (M Ellis pers. obs.). The interval between burns in this trial was eight years, whereas the interval between slashing and burning was three years in treatment A and 1 year in treatment B. There were more seedlings recorded in treatment A in the two years after slashing than in any of the other treatments. In the last assessment in 2012, numbers of seedlings were back to the same level as in the control. Heathland reaches maturity at 8 years and wanes after 33 years; the recommended fire interval for management is 12 to 45 years (Cheal 2010). It is reasonable to conclude that the slash and burn technique does reduce the invasion of Coast Tea-tree, but the information that is missing from this trial is the effect of slashing alone.

After a burn there is a demonstrable increase in species richness in all treatments in the first two years. By the fourth year species richness, although reduced, remains greater than in the control. This may be attributed to the retreat of short-lived ephemerals to a soil seed store, as suggested by Tolsma and Cheal (2012) for the post-fire monitoring at WPNP.

Weeds do not penetrate dense heath and even the bare ground immediately following the fire was not invaded by pest plants. This compares with searches at WPNP after the 2009 fire, which found few weeds, suggesting that vegetation communities on sandy soils are not prone to post-fire weed invasion (Tolsma *et al.* 2011). Slashing and fire had no detrimental effect on the orchid species. Redbeaks seldom flowers without fire, but large numbers appear in a colony following fires (Foster and MacDonald 1999). The Eastern Spider Orchid population on WHNCR is monitored regularly as part of the study by DSE and does not appear to be detrimentally affected by the slash and burn management.

Conclusion

The results from this trial show that these management strategies reduce the invasion by Coast Tea-tree of Sand and Wet Heathland EVCs and enhance species diversity. Weeds were insignificant and would not be a management problem. The slash and burn technique had no detrimental effect on the two orchid species. It would be appropriate to extend the area of management and continue to monitor the results over the long term. We would recommend that the interval between burns be extended to at least 12 years and that an area be set aside for slashing only to determine the effect on Coast Tea-tree recruitment.

Acknowledgements

We would like to thank Danny Drummond, previously Parks Victoria Ranger at WHNCR, for setting up the trial management. We acknowledge the volunteers who came from Friends of Wonthaggi Heathland, South Gippsland Conservation Society and La Trobe Valley Field Naturalists Club. We thank Jim Whelan, Susan Taylor, Peter Homan and Ralph Laby for their constructive comments on the manuscript.

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Curious minds: the discoveries of Australian naturalists

by Peter Macinnes

Publisher: *National Library of Australia, Canberra. 2012, 213 pages, paperback, coloured illustrations, ISBN 9780642277541. RRP $39.99*

Curious minds: the discoveries of Australian naturalists is the most recent in a line of beautifully presented books from the National Library of Australia (NLA) on historical aspects of Australian natural history. The objective is to publish books as part of the process of interpreting and highlighting the NLA collection. This much is part of the charter of the Library, and this book is a fine example of the production standard that has been achieved in fulfilling that role.

The text consists of 26 short biographical essays. The subjects of these pieces are individuals, 39 in number, who are judged to have made contributions to an understanding of Australian natural history, in a 200-year-period beginning in the 1680s. These biographical sketches are grouped in six sections, under headings that are meant to indicate something of the circumstances or type of activity in which the contribution was made. These sections are presented in more-or-less chronological order, following a brief Introduction.

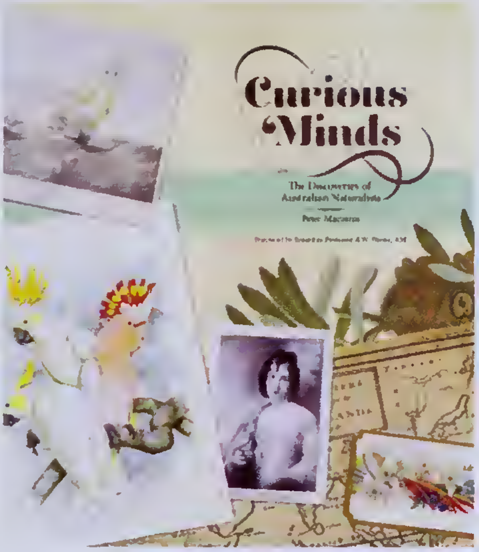
In the first section, 'Australian nature discovered', the focus of attention in four essays is on William Dampier, Willem de Vlamingh, Jacques La Billardière, Claude Riche, Charles-Alexandre Lesueur and Francois Péron. 'Putting Australian nature on the map' (four essays) looks at the roles of Joseph Banks, Sydney Parkinson, James Cook, Charles Darwin, Ferdinand Bauer, Robert Brown, Matthew Flinders, Amelie Dietrich and Georgiana Molloy. Three essays under the heading 'Australia expanded' focus on George Bennett, John White, Thomas Watling, Thomas Huxley, and John Macgillivray. The five essays comprising 'Makers of their own fates' draws attention to Allan Cunningham, Richard Cunningham, Ludwig Leichhardt, John Gilbert, Thomas Mitchell, William Blandowski, and Gerard Krefft. Under the heading of 'True-blue naturalists', the author has included Ferdinand Mueller, Louisa Meredith, Harriet and Helena Scott, Louisa Atkinson, Ellis Rowan and William Macleay. The final section is titled 'Australia live' and looks at John Lewin, John and Elizabeth Gould, George Angus and William Caldwell.

The book concludes with a few paragraphs on 'The value of a curious mind'. Although short, it expresses a number of disparate thoughts; after a couple of readings of the piece, it is still unclear to this reviewer what value is being promoted.

Given the large number of 'curious minds' who might have been included in this book, it is reasonable to assume that those individuals who are featured have been chosen especially by

the author for a reason. It would be interesting to know the author's criteria for his selection.

In some respects, *Curious minds* is a curious book. It is magnificently designed, one might even say over-designed. The six collections of biographies are colour coded: in each section the title banner sets the colour, which is used as a highlighting background for at least one paragraph quotation in that section. Even the motif that brackets the page number picks up the chromatic scheme. It appears that the highlighting of a quotation is about design rather than information by the fact that many other quotes in the same section are not highlighted. When considered against these design elements, as well as the profuse illustrations the pages contain, at times the text by Peter Macinnes seems almost incidental to the book. Where it succeeds is in teasing out the interesting connections that existed between many of the individuals whom Macinnes has chosen to include. The author's forte is in providing a wealth of detail about his subjects, details which anchor them well in the curious mind of the reader. For this, and its illustrations, *Curious minds* is a book of value, to be bought or borrowed.



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Ninety Years Ago

THE LATE MR. W. H. D. LE SOUEF, C.M.Z.S.

AUSTRALIAN natural history has lost, by the death of Mr. W. H. Dudley Le Souef, Director of the Melbourne Zoological Gardens, one of its most ardent investigators and exponents. Mr. Le Souef passed away at his home at the Gardens after a long illness on Thursday, 6th September, at the age of 66. ... Mr. Le Souef had travelled far and wide through the Australian States in search of specimens for the Gardens or to endeavour to solve difficulties regarding native animals, birds, &c. He was always willing to bring natural history before an audience, and it is doubtful whether anyone in Australia has done better service in fostering a love for Nature in its many phases, especially among young people, than Mr. Le Souef. His lectures were generally illustrated by lantern slides from his own photographs, which made them doubly interesting. Though not a " foundation member" of the Field Naturalists' Club, he early joined its ranks, and for many years contributed interesting accounts of his various trips to its meetings. He was elected a member of the committee in 1885, and continued to serve in that capacity for some years. In 1900-1 he acted as co-secretary with the Rev. J. S. Hart, M.A., now Dean of Melbourne, and in 1901-2 in conjunction with the late Rev. W. Fielder. His papers in the Naturalist include visits to Mallacoota, the Mallee, Riverina, Queensland, Western Australia, &c. In these accounts his principal leaning was toward birds, but little escaped his observing eye, and other branches of natural history were not overlooked. ... He also had a considerable acquaintance with Australian ethnology. He took part in the Club expeditions to King Island (1887) and the Kent Group (1890), and later made a trip to Albatross Island with the late Mr. H. P. C. Ashworth. He was an authority on snakes, and compiled the list of Victorian reptiles published in the first volume of the Naturalist (1884). ....

From *The Victorian Naturalist* **XL**, p. 105, October, 1923